Using Torque to Determine the Mass of a Paper Clip

Procedure

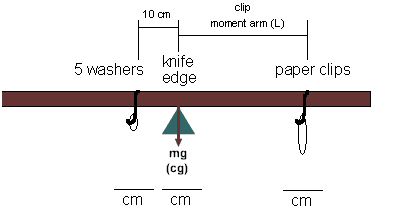
1. Select a meter stick, knife edge and package of 3 washers, and 2 large paper clips. Mass your 3 washers. Record the information below:

3 washers \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_grams

1. Balance your meter stick on the knife edge. You will find that it will balance at its **Center of Mass** which will be about 50 cm. Record the exact location below:

Balance meter stick \_\_\_\_\_\_\_\_\_\_\_\_cm

1. Bend the two large paper clips as shown.



1. Place the clip that is to hold the 3 washers exactly 10 cm from the knife edge. Record its position below. (Remember: you are recording the distance from the knife edge.)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_cm

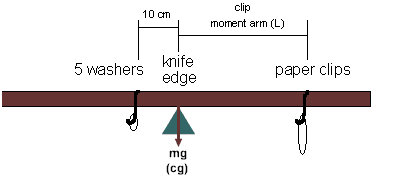
1. Through a combination of moving the balancing clip hanger and varying the number of smaller clips, find eight to ten different locations that balance the three washers. Fill in the chart as you proceed.. (Note: you do not need to include the larger hanging clips in your totals since they cancel each other out.)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Trial | # of clips  N  **X-axis** | Position of clips on meter stick  (cm) | Moment arm of clips  (L) in cm | Reciprocal of moment arm  (1/L) in 1/cm  **Y-axis** |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |
| 5 |  |  |  |  |
| 6 |  |  |  |  |
| 7 |  |  |  |  |
| 8 |  |  |  |  |
| 9 |  |  |  |  |
| 10 |  |  |  |  |

1. You now want to make a graph of **# clips vs 1/moment arm.**  This is most easily done by using Excel, however you may also use graph paper.
2. You now want to calculate the slope of the line, either in Excel or the old fashion way where slope is “rise over the run”
3. The numerical value of the slope of your graph is\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Data Analysis

We now use the data to determine the mass of a single paper clip. We start by noting that we collected data when the meter stick was in equilibrium. That is, the torque on one side of the knife edge equals the torque on the other side.



The **number of clips** times the **mass of one clip** times its **moment arm** is equal to the **mass of 3 washers** times its **moment arm**.

(N) (Mass of one clip) (L) = (Mass of 3 Washers) (10 cm)

Mass of one clip = [(Mass of 3 Washers) (10 cm)] [ 1/L ]

In this equation, [1/L] is the slope of the line of your graph.

To calculate the mass of one paper clip, multiply (10 cm) times the mass of the washers times the slope of your graph in 8 above.

Mass of one paper clip in grams \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_